Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

EVALUATION OF SOME PORTABLE GEOTECHNICAL TESTING TECHNIQUES

B. Das and K.L. Kar

March, 1987

This document is an unedited interim report prepared primarily for circulation and [illegible] reproduction purposes. It does not represent a final report of the opinion of the [illegible] for Mineral and Energy Technology (CANMET)

Ce document est un rapport [illegible] non révisé et rédigé [illegible] pour fin de [illegible] et de documentation [illegible] ne représente nulle[illegible] l'opinion définitive de [illegible] du Centre canadien de la technologie des minéraux et de l'énergie (CANMET)

13 pp

COAL RESEARCH LABORATORIES
DIVISION REPORT CRL 87-31 (TR)

MICROMEDIA

87-05158/

EVALUATION OF SOME PORTABLE GEOTECHNICAL TESTING TECHNIQUES

by

B. Das* and K.L. Kar**

ABSTRACT

Three portable geotechnical testing techniques have been evaluated: point load strength test, Protodyakonov dynamic impact tests and rebound hammer tests. The evaluation criteria for their use in mining have been pointed out. The results of the evaluation are discussed.

---

*B. (Manas) Das, Head, Geotechnical Engineering, CANMET, Coal Research Laboratories, P.O. Bag 1280, Devon, Alberta, Canada.
**K.L. Kar, Technologist, CANMET, Coal Research Laboratories, P.O. Bag 1280, Devon, Alberta, Canada.

ÉVALUATION DE QUELQUES TECHNIQUES PORTATIVES DE TESTS GÉOTECHNIQUES

par

B. (Manas) Das* et K.L. Kar**

RÉSUMÉ

Trois techniques portatives de tests géotechniques ont été évaluées: l'essai de résistance à charge ponctuelle, les tests d'impacts dynamiques Protodyakonov et les essais de marteaux par rebondissement. Les critères d'évaluation pour leur utilisation dans les mines ont été montrés. Enfin, les résultats de cette évaluation sont discutés.

*B. (Manas) Das, Chef, Ingénierie géotechnique, CANMET, Laboratoires de recherche sur le charbon, B.P. Bag 1280, Devon, Alberta, Canada.
**K.L. Kar, Technologue, CANMET, Laboratoires de recherche sur le charbon, B.P. Bag 1280, Devon, Alberta, Canada.

CONTENTS

	Page
ABSTRACT	i
RESUME	iii
CONTENTS	v
INTRODUCTION	1
THE TEST METHODS AND EVALUATION PROCEDURE	2
RESULTS AND DISCUSSION	2
The Point Load Strength Test	2
Protodyakonov Dynamic Impact Test	6
Rebound Hammer Test	6
CONCLUSIONS	6
REFERENCES	9

TABLES

Table 1	Classification of the testing methods for determining rock properties	3
Table 2	The techno-economic selection criteria of the geotechnical testing methods	4
Table 3	A summary of the point load test results on rocks from the coalfields in western Canada	5

FIGURES

Fig. 1	A photographic view of Robertson Research's point load strength tester	7
Fig. 2	Protodyakonov dynamic impact tester for determining the strength of irregular rock samples	7
Fig. 3	Schmidt's hammer for determining rebound strength/ hardness	8

INTRODUCTION

The harnessing of the earth's mineral resources includes the following: geology/exploration, feasibility, mining, mineral processing and utilization. Although rock properties play some role at each of these stages, their role is most significant at the feasibility and mining stages. A systematic knowledge of rock properties is required for the most efficient design of a mining operation. There are several rock mechanics related problems in mining each of which is affected by many properties (1). It may be stressed that no single property is sufficient to describe the behaviour of the rock mass. On the otherhand, the use of too many properties in solving any particular problem is undesirable. The best approach is to incorporate a minimum number of properties to solve a maximum number of problems without eroding reliability. This is an important concept of any rock classification method which has the following necessary steps (1):

- Sorting out the rock mechanics related problems in mining.
- Identifying the rock properties and other factors affecting these problems.
- Developing suitable test methods for determining the properties.
- Establishing functional relationships between these properties/factors and the problems.
- Verifying these correlations in practice.

Developing suitable test methods includes evaluation of the existing methods for some specific purpose as well as developing new methods. All such test methods, can be divided into appropriate groups as presented in Table 1. Some of methods are well established but have not been evaluated for their suitability for determining the properties of rocks whereas some others have not yet been fully evaluated.

CANMET has worked on the evaluation of test methods for rock classification purpose. The point load test method has been systematically studied. Some other test methods such as Protodyakonov dynamic test and the rebound hammer test have been investigated to some extent.

This report presents the results of investigations made so far on some portable testing methods with a view to evaluating their suitability for determining the properties of rocks.

THE TEST METHODS AND EVALUATION PROCEDURE

Different test methods for determining rock properties can be divided into appropriate groups based on the following main criteria: (a) mobility of the instrument, (b) degree of precision, and (c) laboratory or in situ method. (Table 1). There are, however, some latent criteria which have not been pointed out in Table 1 but could influence the selection of the test method. These criteria are presented in Table 2.

The method of evaluation included a review of the existing work, theoretical analysis and practical tests both in the laboratory and in the field.

The results of the following test methods are discussed here:

- The point load test: systematically evaluated.
- Protodyakonov test: preliminary evaluation
- Rebound hammer: preliminary evaluation.

RESULTS AND DISCUSSION

The study results of the three test methods are discussed below.

The Point Load Strength Test

This technique has been thoroughly investigated (2), (Fig. 1). When analyzed on the basis of the criteria in Tables 1 and 2, it may be concluded that this method is a portable one and therefore tests can be performed both in the laboratory and in the field. This is not truly in situ in character although the tests carried out in the field on fresh samples can eliminate the effects of drying and weathering, damage due to transportation, etc. This method can be rated as moderately precise, simple and very cheap. There is no need of sample preparation and the disintegrated pieces of a specimen from a test can be used for further testing. In this sense, this may be classified as semi-destructive, although it is destructive in the truest sense.

The point load strength technique has been found to be generally useful in evaluating strength properties of rocks in Canadian coalfields. Difficulties have been experienced for lignites and weathered rocks.

There are two ways the point load strength can be used: (a) Indirectly through its correlation with the standard geotechnical properties, for example, uniaxial compressive strength, tensile strength, geophysical logging etc. and (b) Directly by establishing relation to specific mining

TABLE 1 - CLASSIFICATION OF THE TESTING METHODS FOR DETERMINING ROCK PROPERTIES

Principal Groups	Sub-groups	Accuracy and Results	Some examples (Method/Instrument)
Laboratory Methods	Fixed or non-portable (instrument)	Very precise	Servo-controlled testing machine, Microhardness test.
	Portable (instrument)	Moderately precise	Point load strength, NCB cone indentor
		Less precise	Rebound hammer, Shore scleresope
		Evaluation incomplete	Protodyakonov test
In Situ Method	Transportable (Transportation and installation is a complicated job).	Very precise	Borehole hydraulic penetrometer, Serata's SPDR system
		Evaluation incomplete	Borehole geophysics
	Portable	Moderately precise	Point load strength
		Less precise	Rebound hammer, Dynamic penetrometer

TABLE 2 - THE TECHNO-ECONOMIC SELECTION CRITERIA OF THE GEOTECHNICAL TESTING METHODS

CRITERION	GROUP
Number of tests required	- Single - A few - Many
Use of the rock properties	- Preliminary evaluation of a property for ownership transfer - General feasibility study - Evaluation of a specific mining method - Design of mine support system - Solution of specific geotechnical problems (e.g. rock burst, caving, subsidence, etc.)
Sample destruction	- Non-destructive test - Destructive test
Availability of sample	- Rare specimens to be preserved - Limited amount of drill cores (from 1-2 hole) - Sufficient amount of drill cores from the entire property - Sufficient amount from an outcrop or different outcrops - Complete range of sample from the different parts of a fully developed mine
Complexity of the test methods and test duration	- Simple and quick (e.g. rebound hammer, point-load strength) - Complex (e.g. standard compressive strength, microhardness test) - Sophisticated and time consuming (e.g. Serata's SPDR system, triaxial test)
Complexity of sample preparation	- Irregular sample (no preparation) - Simple preparation - Sophisticated preparation
Cost	- Very cheap - Moderately expensive - Very expensive
Environmental Restriction	- Can be used in an underground coal mine - Requires special features for use in an explosive atmosphere
Suitability for various rock types	- Complete range - Restricted type

problems, for example, cutting resistance, rock disintegrability, floor strength and others. The test results can be considered suitable for the complete spectrum of uses as indicated in Table 2.

The study indicated that the correlation coefficient ($\delta_u/I_s(50)$) for cement concrete and rocks from the Canadian coalfields depends on the strength of rocks, being higher (18 or more) for harder rocks (e.g. sandstone and siltstone) and lower (as low as 8) for softer rocks (e.g. mudstone)(Table 3).

For point load testing two different load gauges depending upon rock hardness are preferable. A load gauge of 0-5KN appears to be suitable for most rocks encountered in the coalfields in Western Canada.

This method requires a large number of tests for any reliable results. Between 10 to 20 tests on any particular coal measure rock appear to be satisfactory.

TABLE 3 - A SUMMARY OF THE POINT LOAD TEST RESULTS ON ROCKS FROM THE COALFIELDS IN WESTERN CANADA.

Coalfield particulars	Rock Type	$I_s(50)$ (MPa)	σ_u (MPa)	$\frac{\sigma_u}{I_s(50)}$
Coking coal area of the Rocky Mountains*	sandstone	understudy		
	siltstone	1.2	17.6	14.7
	shale/mudstone	understudy		
	coal	0.79	6.2	7.8
Bituminous coal areas of the foothills	sandstone	7.92	142.3	18.0
	siltstone	5.24	85.4	17.3
	shale/mudstone	3.78	46.4	12.6
	coal	2.79	20.3	7.3
Sub-bituminous coal areas of the Plain	sandstone	not available		
	siltstone	3.85	31.6	8.2
	shale/mudstone	1.0	7.1	7.1
	coal	understudy		

* More Tests Necessary

Protodyakonov Dynamic Impact Test

This method was originally developed by Protodyakonov for determining rock properties on irregular samples and is described elsewhere (3) (Fig. 2). In the early Seventies this test was used by Hucka and Das (4) to determine the properties of the western Canadian coals. Subsequently, this technique was imported to Canada by Westar Mining Ltd. from U.S.S.R. via Japan.

Based on the limited evaluation made so far, it may be concluded that this method is only suitable for bituminous coals and brittle sandstone and siltstone. This method is more a laboratory method and can be rated as moderately to less precise. No sample preparation is required for this method which is also very simple and cheap.

Rebound Hammer Test

This is a very simple test and can be used where less precise result is sufficient, for example, in preliminary evaluation of a property. The instrument is portable and test can be made in situ (Fig. 3). The work is inexpensive and very quick. Good correlations may be obtained for some particular rock types, for example, sandstone.

Further study will be required to analyze the division of the energy of the hammer into reversible and irreversible energy in the following processes: plastic deformation, rock disintegration, elastic waves, etc.

CONCLUSIONS

Three portable geotechnical testing techniques have been evaluated: point load strength, Protodyakonov dynamic impact test and the rebound strength. The point load strength method has been studied more throughly and found to be moderately precise, simple, quick and cheap. The other two methods require more study. Based on the preliminary study the latter two methods seem to be less precise. All the three methods are very simple, quick and need no sample preparation. Although these methods can be used for geotechnical testing, further study is required to determine their degree of reliability

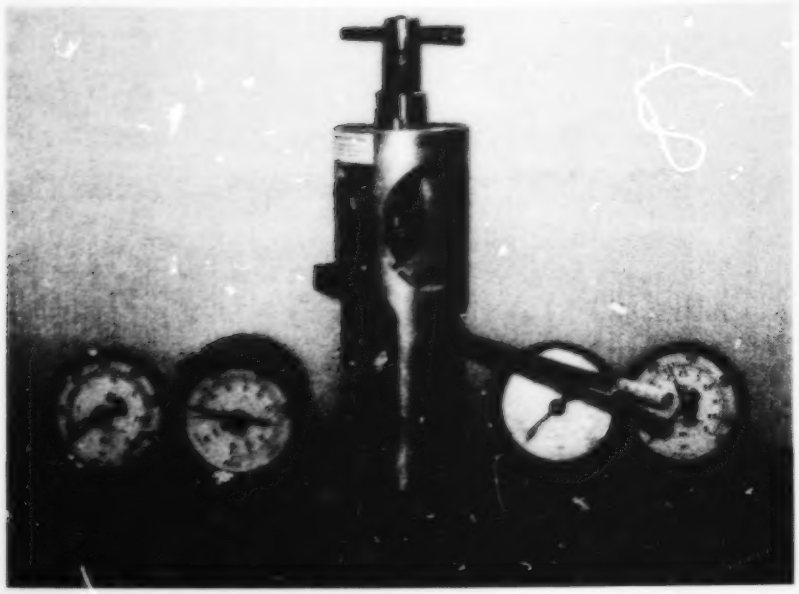

Fig. 1 A photographic view of Robertson Research's point load strength tester.

Fig. 2 Protodyakonov dynamic impact tester for determining the strength of irregular rock samples.

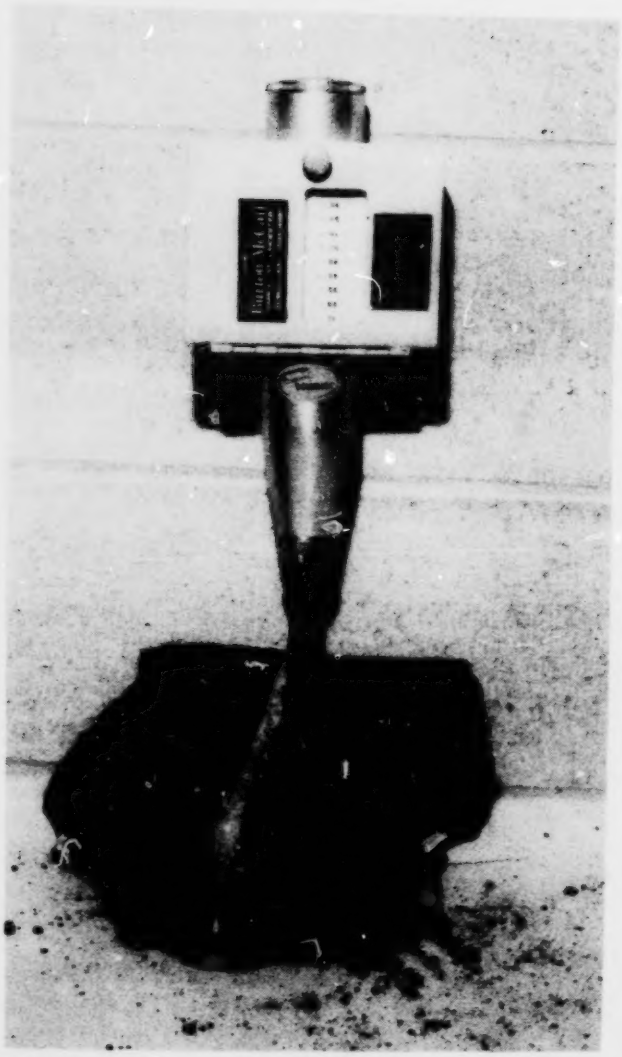

Fig. 3 Schmidt's hammer for determining rebound strength/hardness.

REFERENCES

1. B. Das, "Rock Characterization through Microhardness Techniques". Proc. 27th U.S. Symposium on Rock Mechanics; University of Alabama, Alabama; 121-129; June 23-25, 1986.

2. Das, B. "Evaluation of the point load strength for soft rock classification"; Proc. of the Fourth Conference on Ground Control in Mining; Morgantown, W. Va.; July 22-24, 1985.

3. Protodyakonov, M.M., "Mechanical properties and drillability of rocks"; Proc. 5th Symposium Rock Mechanics; Minneaspolis, Minn. 113-118, 1962.

4. Hucka, V. and Das, B. "Protodyakonov tests on the western Canadian coal's"; Unpublished work; Department of Mining and Mining and Metallurgy, Laval University, Quebec, 1975.